Appendix K

DETAILED LIFE HISTORY DESCRIPTIONS FOR *FISH* ACTION SPECIES

RIVERINE AQUATIC INVERTEBRATES

California Freshwater Shrimp (*Syncaris pacifica*)

The California freshwater shrimp (CFS) is found in pool areas of low-elevation, low-gradient streams, among exposed live tree roots (e.g., willows and alders) of undercut banks, overhanging woody debris, or overhanging vegetation. These streams typically have low summer flows but can transport high flows during the rainy season. Within these low-elevation drainages, the CFS occurs in low-gradient reaches, usually with moderate to heavy overhanging riparian vegetation and a sand and gravel substrate with some mud, silt, and organic debris. Eng (1981) found the shrimp in shallow pools away from the main flow. Furthermore, during winter, shrimp were observed primarily among exposed roots beneath undercut banks or among dense overhanging vegetation, whereas in spring and summer the shrimp were observed primarily on the foliage and branches of bank-side bushes, vines, or sedges that extend into the water (Eng, 1981; U.S. Fish and Wildlife Service, 1998). Willows, California laurel, blackberry, alder, and sedges are plants commonly observed in reaches of good shrimp habitat. Willow roots provide especially good winter habitat for the CFS. Adults also have been observed on submerged twigs and leaf litter.

Existing populations of the California freshwater shrimp are threatened by introduced fish, deterioration or loss of habitat resulting from water diversion, impoundments, livestock and dairy activities, agricultural activities and developments, flood control activities, gravel mining, timber harvesting, migration barriers and water pollution (U.S. Fish and Wildlife Service, 2007b).

Shasta Crayfish (*Pacifastacus fortis*)

Shasta crayfish are found only in Shasta County, California, in the Pit River drainage and two tributary systems, the Fall River and Hat Creek drainages. They live in cool, clear, spring-fed lakes, rivers, and streams, usually at or near a spring, where waters show little annual fluctuation in temperature and remain cool during the summer. Most are found in still and slowly to moderately flowing waters. The most important habitat requirement appears to be the presence of adequate volcanic rock rubble to provide escape cover from predators (U.S. Fish and Wildlife Service, 2007a).

Shasta crayfish is threatened by habitat loss from water diversions, predation, and competition with the exotic signal crayfish (*Pacifastacus leniusculus*) and other species. Two entire populations have been extirpated since, 1978. Many native and introduced fish, amphibians, reptiles, and mammals found in the Pit River region are known to prey on crayfish, although predation on Shasta crayfish has not been documented (U.S. Fish and Wildlife Service, 2007a).

ANADROMOUS OR ESTUARINE NON-SALMONID FISH

Eulachon (*Thaleichthys pacificus*)

The main eulachon population in California is in the Klamath River in Del Norte County, with runs also in the Mad River and Redwood Creek in Humboldt County. The California populations are the southernmost of the species (Moyle et al., 1995).

Eulachon spend most of their life in saltwater, moving up rivers to spawn in large numbers in the spring. In the Klamath River, most eulachon migration takes place in March and April, and the fish seldom penetrate more than 10 to 12 kilometers upstream. The larvae (4–7 mm tail length) stay near the bottom of the water column and are quickly washed to sea by river currents (Moyle et al., 1995).

The factors responsible for the decline of California eulachon populations are unknown. Given the extensive ocean life-phase of the species and the apparently sporadic nature of its abundance in recent years, it is likely that oceanic conditions may be important determinants of the sizes of spawning runs. Yet, it is known that all life stages are sensitive to temperature changes and probably to industrial pollutants. Thus, eulachon are evidently sensitive to a number of environmental factors, and their recent decline in California streams may be due to changes in water quality or spawning habitat in the lower reaches of the rivers they occupy (Moyle et al., 1995).

Green Sturgeon [Southern DPS and Northern DPS] (*Acipenser mediostris*)

The northern distinct population (DPS) of the Green Sturgeon includes the spawning populations in the Klamath and Trinity Rivers. The southern DPS of the Green Sturgeon includes the spawning populations of green sturgeon south of the Eel River (exclusive), principally including the Sacramento River green sturgeon spawning population.

Green sturgeon use both freshwater and saltwater habitat. Green sturgeon live most of their adult lives in nearshore oceanic waters, bays, and estuaries. Mature adult green sturgeon move into large, turbulent freshwater rivers to spawn (Moyle et al., 1992a in Moyle, 2002). Spawning occurs once the fish are more than 15 years old and is then believed to occur every 2 to 5 years (Moyle, 2002). Green sturgeon migrate to fresh water in late February and spawn from March to July, with peak spawning occurring from April to June (Moyle et al., 1995). Each female produces 60,000 to 140,000 eggs (Moyle, 2002). Specific spawning habitat preferences are unclear, but eggs likely are broadcast over bedrock or sand to cobble substrates (Moyle et al., 1995). Juvenile green sturgeon live in fresh and estuarine waters for 1 to 3 years before out-migrating to saltwater (Nakamoto et al., 1995; Moyle, 2002). It is currently believed that green sturgeon spawn in the Klamath River and

Sacramento River basins in California and in the Rogue River in Oregon (National Marine Fisheries Service, 2008a). In the Klamath River a pool 1.5 km upstream of Orleans, CA is known as Sturgeon Hole and is apparently a major spawning site (Moyle, 2002).

Juveniles and adults are benthic feeders, and juveniles have been reported to eat mysid shrimp and amphipods in the Sacramento–San Joaquin River Delta (Delta) (Radtke, 1966 in Moyle, 2002); adults may eat small fish and macroinvertebrates (Moyle, 2002).

The main factor believed responsible for decline of the southern DPS green sturgeon is the reduction in spawning habitat to a limited section in the Sacramento River. There are numerous other threats, including insufficient freshwater flow rates at spawning areas, contaminants, entrainment, impassable barriers, influence of exotic species, small population size, elevated water temperatures, and by-catch of green sturgeon in fisheries, that could potentially affect the status of the southern DPS green sturgeon (Biological Review Team, 2005; 71 FR 17757).

White Sturgeon (*Acipenser transmontanus*)

Although white sturgeon can be found in salt water from Mexico to Alaska, they only spawn in rivers in California's Central Valley northward (Moyle, 2002). In California self-sustaining populations only occur in the Sacramento River (Moyle, 2002).

Typically, white sturgeon can be found on or near areas with soft bottoms. They spend most of their adult lives in saltwater, moving into freshwater rivers to spawn. Their diet consists mostly of shrimp, clams and crabs. Males reach maturity at 10-12 years of age, while females become mature at 12-16 years of age (Moyle, 2002). Once mature, sturgeon move upstream to spawn in deep holes with swift current and rock bottoms. When spawning is complete, adults migrate back into the estuary (Moyle, 2002). Males can spawn every 1-2 years, while females spawn every 2-4 years. Only a small portion of the total population spawns in any one year (Moyle, 2002).

Once the larvae hatch, they swim in a vertical position, drifting toward the estuary (Moyle, 2002). They typically stop in the upper reaches of the estuary where salinity is low. The juvenile's diet consists mostly of shrimp, clams and crabs, expanding to fish when they become adults (Moyle, 2002).

The main threat to white sturgeon is overfishing. Since the time required to reach maturity is so long, sturgeon are slow to rebound from harvest (Moyle, 2002). However, current management practices seem to be sustaining the population.

SALMONIDS

Coho Salmon [Central California Coast ESU] (*Oncorhynchus kisutch*)

The central California coast Coho salmon ESU (CCC Coho ESU) includes all populations from Punta Gorda in northern California south to and including the San Lorenza River in central California, as well as populations in tributaries to San Francisco Bay, excluding the Sacramento–San Joaquin River system (National Marine Fisheries Service, 2008g). From the late 1980s to 2001, adult Coho abundance declined for streams within this ESU; however, some streams of the Mendocino County coast showed an upward trend in 2000 and 2001, and some streams in Marin County also had relatively large adult returns in 2001 (California Department of Fish and Game, 2002). More recently, declines of coastal Coho thought to be the result of unusual ocean conditions have been observed in 2007 (Varanassi and Bartoo, 2007).

In most respects, the life history and ecological requirements of central California coast Coho are similar to southern Oregon/northern California coast Coho salmon in California typically return to their natal streams to spawn after two years in the ocean, but, some return to spawn after the first year, and these are referred to as grilse or jacks (Laufle et al., 1986; California Department of Fish and Game, 2002). Adult migration timing varies between tributaries but generally begins after stream flows increase in fall and early winter and generally occurs from September through January (California Department of Fish and Game, 2002). In small coastal streams, flows must be high enough to breach any sandbars that have formed so migration typically begins mid-November through mid-January (Baker and Reynolds, 1986 in California Department of Fish and Game, 2002). Generally, Coho salmon spawn in smaller streams than do Chinook salmon and spawning primarily occurs from November to January but can extend into March under drought conditions (Shapovalov and Taft, 1954; California Department of Fish and Game, 2002). Fry emerge from gravels between March and July, with peak emergence occurring from March to May, depending on when the eggs were fertilized and the water temperature during development (Shapovalov and Taft, 1954; California Department of Fish and Game, 2002). Similar to other salmonids, fry seek out shallow water at stream margins larger fish move progressively into deeper water. Juvenile rearing areas include low gradient coastal streams, wetlands, lakes, sloughs, side channels, estuaries, low gradient tributaries to large rivers, beaver ponds and large slackwaters (Pacific Fishery Management Council, 1999). Yearling smolts migrate downstream from as early as February to as late as July (DFG unpublished data in California Department of Fish and Game, 2002; Shapovalov and Taft, 1954; Sandercock, 1991 in California Department of Fish and Game, 2002) with peak migration from April to late May/early June (Weitkamp et al., 1995). A small percentage of Coho may rear for more than a year in freshwater (Bell, 2001 in California Department of Fish and Game, 2002; Bell and Duffy, 2007). Central California coast Coho populations are declining in response to the same factors as southern Oregon/northern California coast Coho, along with other factors, such as

habitat loss and degradation, the conversion of forest to agricultural lands (especially vineyards), hatchery domestication effects, catch-and-release incidental mortality, climatic variation, and predation (Moyle et al., 2008; National Marine Fisheries Service, 2008g; California Department of Fish and Game, 2002).

Coho Salmon [Southern Oregon/Northern California Coast ESU] (*Oncorhynchus kisutch*)

The southern Oregon/northern California coast Coho salmon ESU includes all naturally spawned populations in coastal streams from Cape Blanco in Curry County, Oregon, and Punta Gorda in Humboldt County, California, and three artificial propagation programs: Cole River Hatchery in the Rogue River basin and the DFG Trinity River Hatchery and Iron Gate Hatchery in the Klamath–Trinity River basin (National Marine Fisheries Service, 2008h). The estimated historical and recent mean run abundance are 150,000 and 5,170, respectively (National Marine Fisheries Service, 2008h). The Klamath and Trinity River populations are largely maintained by hatchery production: Fish of hatchery origin account for 80% of fish returning to Iron Gate Hatchery and 89% to 97% of fish returning to Trinity River Hatchery (Moyle et al., 2008).

Coho salmon in California typically return to their natal streams to spawn after 2 years in the ocean, but some return to spawn after the first year, and these are referred to as grilse or jacks (Laufle et al., 1986; California Department of Fish and Game, 2002). Adult migration timing varies between tributaries but generally begins after stream flows increase in fall and early winter and generally occurs from September through January (California Department of Fish and Game, 2002). In small coastal streams, flows must be high enough to breach any sandbars that have formed, so migration typically begins mid-November through mid-January (Baker and Reynolds 1986 in California Department of Fish and Game, 2002; California Department of Fish and Game, 2002). In the Klamath River, southern Oregon/northern California coast Coho salmon adults migrate between September and late December, with a peak in late September to early October. In the Eel River, migration begins 4–6 weeks later, with a peak in upper reaches occurring in November–December (Baker and Reynolds, 1986 in California Department of Fish and Game, 2002).

Spawning in small coastal streams occurs mainly from November to January but may occur as late as March, depending on flow and access conditions (Shapovalov and Taft, 1954; California Department of Fish and Game, 2002). In both the Klamath and Eel rivers, spawning primarily occurs in November and December (Baker and Reynolds, 1986 in California Department of Fish and Game, 2002; U.S. Fish and Wildlife Service, 1979).

Coho salmon migrate and spawn mainly in smaller streams than Chinook salmon, including those that flow directly into the ocean or in tributaries of large rivers.

Females choose redd sites with coarse, mixed-size gravel (up to 15 cm average diameter, up to 5% fines), often at pool tailouts (Moyle et al., 2008). Spawning typically occurs in water 10–54 cm deep, with flow velocities of 0.2–0.8 meters/second. Incubation lasts 8 to 12 weeks, depending on temperature and local adaptations, and fry emerge between March and July, with peak emergence occurring from March to May (Shapovalov and Taft, 1954; California Department of Fish and Game, 2002). Juveniles initially rear in shallow stream margins. As they grow, parr shift into deeper water until July and August, when they are in the deepest pools (California Department of Fish and Game, 1994 in California Department of Fish and Game, 2002) with instream cover (undercut banks, logs, and other woody debris). During winter, juveniles seek refuge from high, turbid flows in areas with lowered velocities and less turbidity, such as in side channels, masses of large woody debris, and small tributaries (Moyle et al., 2008). Rearing areas generally used by juvenile Coho salmon are low-gradient coastal streams, wetlands, lakes, sloughs, side channels, estuaries, low-gradient tributaries to large rivers, beaver ponds, and large slackwaters (Pacific Fishery Management Council, 1999). Juveniles optimally rear at temperatures around 12°C to 14°C but have been found at temperatures as high as 29°C (Bisson et al., 1988; Moyle, 2002). Juveniles typically migrate to the ocean at age 1+ but may defer another year. Juvenile migration typically begins in late March and early April but may begin prior to March (California Department of Fish and Game unpublished data in California Department of Fish and Game, 2002). Peak juvenile migration occurs from April to late May/early June (Weitkamp et al., 1995; California Department of Fish and Game, 2002) and can persist into July in some years (Shapovalov and Taft, 1954; Sandercock, 1991). Bell (2001) has found a small percentage of Coho salmon that remain more than 1 year in Prairie Creek before going to the ocean and suggests that this can occur when fish are spawned late and are too small at time of smolting (California Department of Fish and Game, 2002).

Factors contributing to the decline of southern Oregon/northern California coast Coho salmon include poor land-use practices (especially those related to logging and agriculture), dams and diversions, in-stream structures, gravel mining, suction dredging, substandard or unscreened diversions, overharvest and poaching, water over-allocation and pollution, nonnative species, and urbanization (Brown et al., 1994; Moyle et al., 2008; National Marine Fisheries Service, 2008h).

Chinook Salmon [Klamath–Trinity Rivers Spring-Run ESU] (*Oncorhynchus tshawytscha*)

The Klamath–Trinity Rivers (KTR) spring-run Chinook salmon ESU includes naturally reproducing populations of salmon in the Klamath and Trinity rivers. Adult KTR Chinook salmon enter the Klamath estuary from March to July, with a peak between May and early June (Moyle et al., 2008; Myers et al., 1998). Once they reach the upper portions of the watershed, they remain in cold-water areas for 2 to 4 months before spawning. Optimal adult holding habitat is characterized by pools

or runs over 1 m deep with summer temperatures less than 20°C, shade, little human disturbance, and ample cover (e.g., bedrock ledges, boulders, or large woody debris) (West, 1991).

Spawning starts in mid-September in the Salmon River and in early October in the Trinity River basin. For KTR spring-run Chinook, a majority of spawning habitat is found on low-gradient gravel riffles and at pool tailouts (Moyle et al., 2008). With optimal conditions, embryos hatch after 40–60days and remain in the gravel for another 4–6 weeks until emerging from early winter until late May (Leidy and Leidy 1984). Juvenile downstream migration occurs primarily from February through mid-June (Leidy and Leidy, 1984) with entry into the Klamath estuary when river water temperatures are at or above optimal holding temperatures (Moyle et al., 2008).

The KTR spring-run Chinook have been largely extirpated from their historic range because their life history makes them extremely vulnerable to the combined effects of dams, mining, habitat degradation, and harvest (Moyle et al., 2008).

Chinook Salmon [California Coastal ESU] (*Oncorhynchus tshawytscha*)

The California coastal Chinook salmon ESU includes all naturally spawned populations from rivers and streams south of the Klamath River (exclusive) to the Russian River (inclusive), as well as those associated with five artificial propagation programs, at the Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, and Mattole Salmon Group hatcheries (National Marine Fisheries Service, 2008i).

California coastal Chinook are fall-run salmon, and adults return to their natal rivers between September and early November after sandbars at estuarine river mouths have been breached by storm or peak flow events (Moyle et al., 2008). California coastal Chinook salmon may spawn immediately or may rest in holding pools for a considerable time if flows allow river entry but do not initially permit access to spawning habitat farther upstream. Chinook use the largest substrate of any California salmonid for spawning, which includes a mixture of small cobble and large gravel. For California coastal Chinook, a majority of spawning habitat is in the upper main stems of rivers and lower reaches of coastal creeks. Preferred spawning habitat is at depths of 30–100 cm and water velocities of 40 to 60 cm/sec (Moyle et al., 2008). Under optimal conditions, incubation lasts 40–60 days, and fry emerge 4–6 weeks later in late winter or spring. Fry first use shallow nearshore waters, but as they grow larger, they move into the tails of pools or other moderately fast-flowing habitats where food is abundant and there is some protection from predators. Most California coastal Chinook salmon begin migrating downstream within a week to months of emergence at sizes ranging from 30 to 50 millimeters fork length. California coastal Chinook and may reside in estuaries, lagoons, and bays for several months, feeding and growing considerably, before continuing into the ocean (Moyle

et al., 2008). California coastal Chinook are threatened by the same factors affecting Northern California steelhead, and they are also affected by non-federal timber harvest (National Marine Fisheries Service, 2008i).

Chinook Salmon [Sacramento River Winter-Run ESU] (*Oncorhynchus tshawytscha*)

The Sacramento River winter-run Chinook salmon ESU includes all naturally spawned populations in the Sacramento River and its tributaries, as well as two artificial propagation programs: winter-run Chinook from the Livingston Stone National Fish Hatchery and winter-run Chinook in a captive brood stock program maintained at Livingston Stone National Fish Hatchery and the University of California, Davis, Bodega Marine Laboratory.

Winter-run Chinook occur in areas that have a continuous supply of cold water, such as the spring-fed streams of the basalt and porous lava region of northeastern California (Moyle et al., 2008). They occur only in the Sacramento River basin because they require water temperatures cold enough in summer to enable successful incubation but warm enough in winter to support juvenile rearing (Moyle et al., 2008; Stillwater Sciences, 2006). Winter-run Chinook historically migrated high into the watersheds of the McCloud, Pit, and upper Sacramento rivers to spawn. This habitat was lost to them with the construction of Shasta Dam in the 1940s (Moyle et al., 2008).

Winter-run Chinook life history timing differs considerably from the other three Central Valley Chinook salmon races. Their spawning migration extends from January to May with a peak in mid-March. They enter fresh water as sexually immature adults and migrate upriver to the reaches below Keswick Dam, where they hold for several months until spawning in April through early August (Moyle et al., 2008; Williams, 2006). Optimal temperatures for holding range from 10°C to 16°C, and optimal water velocities range from 0.47 to 1.25 meters/second (U.S. Fish and Wildlife Service, 2003a). Incubation, which is the most temperature-sensitive life history stage, occurs in the hottest part of the year (Moyle et al., 2008). To ensure moderate redd temperatures, winter-run Chinook spawn at depths of 1 to 7 meters (Moyle, 2002). Fry emerge from the gravel from July through mid-October (Moyle et al., 2008; Williams, 2006; Yoshiyama et al., 1998). After emergence, juveniles are restricted in their rearing habitat to those reaches that maintain cool summer temperatures. According to Williams (2006), most fry migrate past Red Bluff Diversion Dam in summer or early fall, but many rear in the river below Red Bluff for several months before they reach the Delta in early winter. Juvenile entry into the Delta occurs from January to April. Little is known about current juvenile usage of the San Francisco estuary, but a recent study by the U.S. Army Corps of Engineers (USACE) indicates that residence time is limited and outmigration through this region is swift (Moyle et al., 2008).

The biggest single cause of winter Chinook salmon decline was the loss of access to spawning areas caused by construction of the Shasta and Keswick dams in the 1940s. Other, ongoing factors include having only one existing population with a low population size, climate variability (e.g., drought), unscreened or inadequately screened water diversions, predation, pollution (e.g., from the Iron Mountain Mine), adverse flow and water quality conditions leading to high water temperatures, fisheries management, passage barriers (e.g., Red Bluff Diversion Dam), and degraded spawning habitat (Moyle et al., 2008; National Marine Fisheries Service, 2008k).

Chinook Salmon [Central Valley Spring-Run ESU] (*Oncorhynchus tshawytscha*)

The Central Valley spring-run Chinook salmon ESU includes all naturally spawned populations in the Sacramento River and its tributaries in California, including the Feather River, and one artificial propagation program: the DFG Feather River Hatchery spring-run Chinook salmon program. There are only three remaining independent populations, Mill, Deer, and Butte Creeks, which are in close geographic proximity to each other. Estimates of historic abundance indicate about 700,000 spawners, which has declined to a current level of and 500 to 4,500 spawners (National Marine Fisheries Service, 2008j).

Returning Central Valley spring-run Chinook migrate upstream as sexually immature fish in spring, hold through the summer in deep pools, spawn in early fall, and migrate downstream as juveniles after either a few months or a year in fresh water (Moyle et al., 2008). Spawning migration extends from February to early July with peaks in mid-April in Butte Creek and in mid-May in Deer and Mill Creeks (Williams, 2006). Central Valley spring-run Chinook attain maturity at ages of 2 to 4 years. They generally migrate higher into watersheds than other runs in order to find deep pools where cooler temperatures allow over-summering (Moyle et al., 2008). Spawning often occurs in the tail waters of their final holding pool (Moyle, 2002). Preferred spawning habitat seems to be at depths of 25–100 cm and at water velocities of 30–80 cm/sec (Williams, 2006). Incubation lasts 40–60 days and is extremely sensitive to temperature, with high egg mortality at temperatures above 14 to 16°C. Fry emerge in another 4-6 weeks (Williams, 2006). Migration can begin within hours of emergence, after a few months of natal rearing, or after over-summering in the natal stream (Hill and Webber, 1999; Moyle et al., 2008; Stillwater Sciences, 2006). As Central Valley spring-run Chinook travel downstream, they may rear in the lower reaches of non-natal tributaries and along main-stem margin habitats, particularly for smaller fish that need to grow larger before ocean entry (Moyle et al., 2008). Juveniles feed mainly on zooplankton, benthic invertebrates, terrestrial drift, and larvae of other fishes, especially suckers (Moyle, 2002; Moyle et al., 2008).

According to the NMFS (2008), there are three primary limiting factors to Central Valley spring-run Chinook: (1) loss of most historic spawning habitat due to

impassable dams, (2) degradation of remaining habitat, and (3) genetic threats from the Feather River Hatchery spring-run Chinook salmon program. Other limiting factors include water diversions, unscreened or inadequately screened water diversions, excessively high water temperatures, predation by nonnative species, urbanization and rural development, logging, grazing, agriculture, mining, estuarine alteration, fisheries management, and "natural" factors (Moyle et al., 2008; National Marine Fisheries Service, 2008j).

Chinook Salmon [Central Valley Fall-/Late Fall–Run ESU](*Oncorhynchus tshawytscha*)

The Central Valley fall-/late fall–run Chinook salmon ESU includes all populations in the Sacramento and San Joaquin River basins and their tributaries. Fall-run Chinook are the most abundant run in the Central Valley and are the principal run raised in hatcheries (Moyle, 2002; Williams, 2006). However, the fall-run Chinook population has declined during the last several years from an average of 450,000 (1992–2005), to less than 200,000 fish in 2006 and to about 90,000 spawners in 2007. The population includes both wild and hatchery-origin fish, and the proportion of hatchery fish can be as high as 90% depending on location, year, and surveyor bias (Barnett-Johnson et al., 2007 in Moyle et al., 2008).
Fall-run Chinook habitat requirements are generally similar to those of California coastal Chinook, but juveniles make more extensive use of off-channel habitats where they grow faster because of warmer water temperatures and abundant food (Moyle et al., 2008; Sommer et al., 2001).

Fall-run Chinook migrate to spawning grounds as sexually mature adults and usually spawn 1 to 2months after entry. Peak spawning time is from October to November, but spawning can continue through January. Fry typically emerge from December through March and rear in natal streams for 1 to 7 months, usually moving downstream into the main rivers within a few weeks after emergence. Both fry and smolts can be found in the San Francisco estuary. Fish spend 2 to 5 years at sea before returning to spawn (Moyle et al., 2008).

Limiting factors affecting the fall-run/late fall–run Chinook salmon include hatcheries, harvest, and reduced spawning and rearing habitat due to agriculture and water management actions (West Coast Chinook Salmon Biological Review Team, 1999).

Steelhead [Southern California DPS] (*Oncorhynchus mykiss irideus*)

The southern California steelhead DPS includes all naturally spawned populations below natural and human-made impassable barriers in streams from the Santa Maria River near San Luis Obispo, California (inclusive), south to the U.S. border with Mexico. Runs have declined from 55,000 fish in historical time to fewer than

500 fish now, and the DPS has been extirpated from more than half of the 46 watersheds that historically supported steelhead runs (National Marine Fisheries Service, 2008f).

Southern California steelhead depend on winter rains to provide upstream passage through seasonally opened estuaries and flowing main-stem rivers. Southern California steelhead typically spawn between January and May, with a peak in February through mid-April (Santa Ynez River Technical Advisory Committee, 2000 in Moyle et al., 2008). Rivers within the range of southern steelhead are presumably warmer than streams farther north, and these warmer temperatures likely decrease incubation time with emergence occurring in as little as 3 weeks (Barnhart, 1986). Southern California steelhead probably out-migrate relatively early because of the inhospitable conditions created by low flows and warm temperatures in their natal streams. These conditions can result in a greater dependence on coastal lagoons compared with more northern steelhead populations (Moyle et al., 2008).

Southern California steelhead have habitat requirements similar to those of other salmonids (e.g., cool, clear, well-oxygenated water, and ample food) but may have a broader physiological tolerance because of their highly variable environment (Moyle et al., 2008). Optimal water temperatures for juvenile steelhead are reported as 10°C–17°C, but southern steelhead have been found in waters as warm as 28°C (Carpanzano, 1996 in Moyle et al., 2008; Moyle et al., 2008; Santa Ynez River Technical Advisory Committee, 2000 in Moyle et al., 2008; Spina, 2007). Southern steelhead primarily spawn and rear in higher-elevation headwaters, but access to these waters is limited by artificial barriers (Moyle et al., 2008).

Southern California steelhead typically outmigrate to lagoonal estuaries between January and June, with a peak from late March through mid-May (Santa Ynez River Technical Advisory Committee, 2000 in Moyle et al., 2008). Because of the unpredictability of the environmental conditions in the southern rivers, it is likely that during wet years, a high percentage of the southern steelhead returning to spawn have spent only 1 year in the ocean (Moyle et al., 2008).

The NMFS (2007) identified varied threats to southern California steelhead, including urbanization, dams and other barriers, stream habitat loss, estuarine habitat loss, species interactions, hatcheries, drought, climate change, and wildfire.

Steelhead Salmon [Northern California DPS] (*Oncorhynchus mykiss irideus*)

The Northern California steelhead DPS includes all naturally spawned populations of steelhead in California coastal river basins from Redwood Creek (inclusive) southward to the Russian River (exclusive) and those associated with two artificial propagation programs: the Yager Creek Hatchery and the north fork Gualala River Hatchery. The Northern California steelhead consists primarily of winter-run steelhead, but summer-run steelhead also occur in some tributaries, including

Redwood Creek and the Mad, Van Duzen, middle fork Eel, and Mattole rivers, and possibly also the north fork Eel, upper main-stem Eel, and south fork Eel rivers (Moyle et al., 2008). Little quantitative abundance information exists, but Busby et al. (1996) concluded that population abundances were low relative to historical estimates.

Adult Northern California winter-run steelhead enter estuaries and rivers as sexually mature adults between September and March (Busby et al., 1996) and spawn primarily between December and early April but occasionally into May (Busby et al., 1996). Adult steelhead require high flows with water at least 18 cm deep for passage (Bjornn and Reiser, 1991). Steelhead generally spawn in pooltails, and redds usually are built in water depths of 0.1 to 1.5 meters where velocities are between 0.2 and 1.6 meters/second and in substrate between 0.6 to 12.7 cm in diameter (Moyle et al., 2008). Steelhead embryos incubate for 18 to 80 days depending on water temperatures (optimal in the range of 5°C to 13°C; McEwan and Jackson, 1996), and emergence from the gravel occurs after 2 to 6 weeks (Moyle, 2002; McEwan and Jackson, 1996). Newly emerged fry generally school together along shallow-margin habitat, while larger juveniles maintain territories in faster and deeper locations in pool and run habitats favoring areas with cool, clear, fast-flowing water, ample cover (riparian vegetation and undercut banks), and abundant food (Moyle, 2002). Juveniles typically rear in streams for 2 years and migrate to the ocean or estuary during high spring flows with movement peaking during late April or May. Young-of-year steelhead will emigrate to estuaries as late as June or July (Moyle et al., 2008).

Adult Northern California summer-run steelhead migrate into the upper middle fork Eel River as sexually immature adults from mid-April through June, and potentially into July (Jones and Ekman, 1980 in Moyle et al., 2008; Puckett, 1975 in Moyle et al., 2008). Spawn timing has not been well documented but is assumed to occur in similar months to winter-run steelhead. Basic habitat requirements are believed similar to those of other steelhead, with the exception that over-summering habitat needs to support fish survival under unfavorable low flow and higher water temperature conditions. Cold tributary confluences and deep pools provide over-summering habitat for Northern California summer-run steelhead. (Moyle et al., 2008.)

In small estuaries where Northern California steelhead occur, a summer lagoon typically forms as a result of sandbar formation at river mouths, which prevents juvenile movement into the ocean, and steelhead may hold in these estuaries for 1 or more years. Northern California steelhead can spend up to 4 years in the ocean, and spawning adults typically return to the same stream into which they were reared, where they may spawn 2–4 times in their lifetime (Moyle et al., 2008).

Factors contributing to the decline of Northern California steelhead include agricultural and forestry operations, artificial barriers (dams; erosion and flood-control structures; pits from gravel mining; road crossings, including bridges;

culverts; and low-water fords), gravel extraction, suction dredging, illegal harvest, unscreened or substandard fish screens on diversions, water over-allocation and pollution, urbanization, potential genetic modification in hatchery stocks, incidental mortality from catch-and-release hooking, climatic variation leading to drought, flooding, and variable ocean conditions, and predation (National Marine Fisheries Service, 2008d).

Steelhead Salmon [South/Central California Coast DPS] (*Oncorhynchus mykiss irideus*)

The south-central California coast steelhead DPS includes all naturally spawned populations in coastal river basins from the Pajaro River southward to, but not including, the Santa Maria River dividing Santa Barbara and San Luis Obispo Counties (National Marine Fisheries Service, 2007b). Estimated historical runs of 27,000 adults declined to less than 500 fish by 1996 with all four of the largest watersheds (Big Sur, Little Sur, Arroyo Seco, and Carmel rivers) experiencing declines of 90% or more (National Marine Fisheries Service, 2008e). In the Carmel River, counts at San Clemente Dam subsequently increased to a peak of 800 in 1997 but declined again after 2001 with less than an estimated 200 adults returning in 2009 (Williams, 2009). Current population trends in other individual watersheds are generally unknown but may be similar to the Carmel River.

South-central California coast steelhead have ecological requirements similar to those of Northern California steelhead described above with the exception that steelhead in more southern areas are exposed to warmer water temperatures than their northern counterparts and may have adapted greater tolerance levels for warmer summer temperatures. During the summer, warm air temperatures can heat up south-central coastal streams to temperatures close to steelhead thermal tolerance limits or above; therefore, over-summering thermal refuge habitat is important.

South-central California coast steelhead and central California coast steelhead encounter similar physical habitat features that influence their juvenile life history, including small, steep coastal watersheds, which result in outmigration by relatively young and small juveniles; and rearing within seasonally closed estuaries, which influences patterns of smoltification, marine survival, and migration (Moyle et al., 2008).

Adults return to spawn between January and May (Boughton et al., 2006; Moyle et al., 2008). Due to warmer stream water temperatures, incubation is shorter than in more northern populations. Optimal mean monthly rearing temperatures are between 6°C and 10°C (Moyle et al., 2008; National Marine Fisheries Service, 2007c). High flow events, which do not occur every year, are required to breach estuarine lagoon barriers. When barriers are not breached, migratory access between the ocean and fresh water is impossible. In these cases, migrating adults

are thought to spend another year in the ocean before returning to try again and that older juveniles prevented from entering the ocean may experience high mortality (Moyle et al., 2008). However, some juveniles are able to over-summer in the estuary of their natal creek where temperatures may at times be near their thermal tolerance (~25°C) (Myrick and Cech 2004) but food is abundant; these conditions allow fish to grow fast enough during their first year of lagoon rearing to migrate to the ocean (Bond 2006). Most of these "lagoon anadromous" fish enter the ocean at a larger size than their freshwater rearing counterparts; larger size upon ocean entry enhances survival, as evidenced by a large proportion of lagoon-reared fish returning to the steelhead spawning population (Bond, 2006).

The National Marine Fisheries Service (NMFS) (2007) identified several factors affecting south-central California coast steelhead, including alteration of natural stream flow patterns; physical impediments to fish passage; alteration of floodplains and channels; sedimentation and urban and rural waste discharges; spread and propagation of alien species resulting in predation, competition, and disease transmission; and loss of estuarine habitat.

Steelhead Salmon [Central Valley DPS] (*Oncorhynchus mykiss irideus*)

The Central Valley steelhead DPS includes all naturally spawned anadromous steelhead below natural and manmade impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries but including two artificial propagation programs: the Coleman National Fish Hatchery, and the DFG Feather River Hatchery. Estimates of historical and recent mean run abundance are 1–2 million and approximately 3,600, respectively (National Marine Fisheries Service, 2008c).

The habitat requirements of Central Valley steelhead are similar to those of central California coast steelhead. Water quality is a critical factor during the freshwater residence time with cool, clear, and well-oxygenated water needed for maximum survival (Moyle, 2002). Juvenile steelhead (ages 1+ and 2+) occupy deeper water than fry and show a stronger preference for pool habitats with ample cover, as well as for rapids and cascade habitats (Dambacher, 1991). Juveniles generally occupy habitat with large structures such as boulders, undercut banks, and large woody debris that provide feeding opportunities, segregation of territories, refuge from high water velocities, and cover from fish and bird predators (Moyle et al., 2008).

Central Valley steelhead exhibit flexible reproductive strategies that allow for persistence in spite of variable flow conditions (McEwan, 2001). Peak adult migration historically occurred from late September to late October, with some creeks, such as Mill Creek, showing a small mid-February run (Hallock, 1989 in Moyle et al., 2008). Optimal spawning temperatures are 4˚C to 11˚C (McEwan and Jackson, 1996). Emergent fry migrate into shallow water (<36 cm) areas such as the stream edge or low gradient riffles, often in open areas with coarse substrates

(Everest and Chapman, 1972, Everest et al., 1986, and Fontaine, 1988, all in Moyle et al., 2008). In the late summer and fall, juveniles move into higher-velocity, deeper, mid-channel areas (Everest and Chapman, 1972, Fontaine, 1988, and Hartman 1965, all in Moyle et al., 2008). Age data from a sample of 100 fish taken in 1954 indicated that steelhead spent 1 (29%), 2 (70%), or 3 (1%) years in freshwater before migrating out of the basin to the ocean (Hallock et al., 1961). Juvenile Central Valley steelhead generally migrate from late December through the beginning of May, with a peak in mid-March (Moyle et al., 2008).

Central Valley steelhead are opportunistic predators of aquatic and terrestrial insects, small fish, frogs, and mice, but their primary diet consists of benthic aquatic insect larvae, particularly caddisflies (*Trichoptera*), midges (*Chironomidae*), and mayflies (*Ephemeroptera*) (Merz, 2002). Depending on season and steelhead size, they also may eat salmon eggs, juvenile salmon, sculpins,and suckers (Merz, 2002).

The primary limiting factor for Central Valley steelhead is the inaccessibility of more than 95% of its historic spawning and rearing habitat due to major dams (National Marine Fisheries Service, 2008c). Other limiting factors include small passage barriers, water development and land use activities, levees and bank protection, dredging and sediment disposal, mining, contaminants, fisheries management practices, hatcheries, inadequately screened water diversions, and predation by nonnative species (McEwan, 2001; Moyle et al., 2008; National Marine Fisheries Service, 2008c).

Steelhead Salmon [Central California Coast DPS] (*Oncorhynchus mykiss irideus*)

The central California coast steelhead DPS includes all naturally spawned populations below natural and manmade impassable barriers in California streams from the Russian River (inclusive) south to Aptos Creek (inclusive); the drainages of San Francisco, San Pablo, and Suisun Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin rivers; tributary streams to Suisun Marsh, including Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough (commonly referred to as Red Top Creek), excluding the Sacramento–San Joaquin River basin and those fish associated with two artificial propagation programs: the Don Clausen Fish Hatchery and Kingfisher Flat Hatchery/Scott Creek (Monterey Bay Salmon and Trout Project) steelhead hatchery programs. There are few quantitative abundance data, but estimated runs in the Russian River declined from 65,000 in the 1960s to 1,750–7,000 in the 1990s, indicating a potential loss of at least 89% (Busby et al., 1996; National Marine Fisheries Service, 2007a).

Central California coast steelhead require freshwater spawning and rearing sites similar to those described for Northern California steelhead. Like other salmonids, central California coast steelhead require cool water for health, growth, and

reproduction, though they tolerate warmer water conditions as well. Generally, central California coast steelhead juveniles are absent from waters that exceed 25°C–26°C for even short periods (Moyle et al., 2008). For adult steelhead, lethal temperatures are 23°C –24°C (Moyle, 2002). Estuaries provide critical nursery areas for juvenile steelhead. Estuaries along the central California coast vary in size but tend to undergo sandbar formation and become seasonal freshwater lagoons during summer low flow conditions. Although estuaries provide nursery habitat, fish cannot remain there for their entire life, and sandbars must be breached by high stream flows on a recurring basis so that adult spawners can migrate upstream to spawn and juveniles can migrate to the sea (Moyle et al., 2008).

The majority of central California coast steelhead enter rivers as sexually mature adults between late December and April (Moyle et al., 2008) and spawn soon after reaching spawning grounds. Peaks in adult migration were observed in Wadell Creek in early January and mid-March (Shapovalov and Taft, 1954).Depending on water temperature (Shapovalov and Taft, 1954),incubation time ranges from 25 to 35 days. Alevins spend 2 to 3 weeks in the gravel before emerging as fry, which start to move into the water column and occupy deeper water as they grow.

Juvenile downstream migration may occur throughout the year, but the primary migration season occurs in spring and summer, with a secondary migration in the late fall or early winter (Shapovalov and Taft, 1954). Hayes et al., (2008) has described three life history expressions: Some juvenile steelhead migrate to the estuary after spending only a few months in the upper watershed, some migrate after spending 1 to 2 years rearing in the upper watershed, and some rear for at least a year in the upper watershed before migrating downstream. The first two types also will rear in the estuary for 1 to 10 months before ocean entry, whereas the third type immediately enters the ocean upon migration without rearing in the estuary. Central California coast steelhead are threatened by the same factors that affect Northern California steelhead (National Marine Fisheries Service, 2008b).

Steelhead Salmon [Klamath Mountain Province DPS](*Oncorhynchus mykiss irideus*)

The Klamath Mountain Province (KMP) steelhead DPS includes all naturally spawned populations found in coastal rivers and creeks throughout the Klamath River and Trinity River basins and streams from north of the mouth of the Klamath River to the Elk River near Port Orford, Oregon, including the Smith River in California and the Rogue River in Oregon (Moyle et al., 2008). This DPS consists of two run types: the summer-run and winter-run, which are designated according to the state of sexual maturity at the time of river entry (i.e., the summer run enters the river in a sexually immature state and requires several months before ripening to spawning condition; while winter run enters the river sexually mature and spawns shortly after reaching the spawning grounds) but may overlap in their migration and spawning periods. Both summer- and winter-run populations have declined;

however, the summer run has declined more substantially, with only a few populations large enough to persist for more than 10–25 years under existing conditions (Moyle et al., 2008).

According to Busby et al., (1994), there is uncertainty regarding run-type designation for steelhead in the Klamath and Trinity rivers. Some biologists contend that fall-run steelhead should be designated as a separate run (Heubach, 1992) or should be considered winter steelhead, while other biologists believe that spring- and fall-run steelhead in the Klamath Mountain Province (KMP) are actually summer-run steelhead based on lack of segregation at spawning (Everest, 1973 in Busby et al., 1994; Roelofs, 1983 in Busby et al., 1994). The National Marine Fisheries Service uses the latter for designating run types in the KMP (Busby et al., 1994).

In California, KMP summer steelhead typically enter fresh water in a sexually immature condition between April and June; however, in the Trinity River, they enter between May and October (Moyle et al., 2008). Over-summering habitat for adult summer steelhead needs to support fish during periods of unfavorable conditions (low flows and higher water temperatures); important factors include deep pools (>1m), low substrate embeddedness (<35%), presence of riparian habitat shading, and instream cover associated with increased velocity through the occupied pools (Baigun, 2003; Nakamoto, 1994). Summer steelhead spawning begins in late December and peaks in January, except in the Trinity River, where peak spawning occurs in February. KMP summer steelhead spawn in upstream regions where winter steelhead generally do not spawn, including intermittent streams whence the juveniles emigrate to perennial reaches soon after hatching (Everest, 1973; Roelofs, 1983). Water velocity and depth measured at redds are 23–155 cm/sec and 10–150 cm, respectively, and gravel size is typically 0.64–13 cm.

KMP winter steelhead are sexually mature when they enter fresh water between September and March, and they spawn shortly thereafter (Busby et al., 1996). In the Trinity River, the spawning peak occurs in March, and fry emerge starting in April and migrate downstream beginning in May (Moffett and Smith 1950). Fry generally are found along stream margins while larger juveniles "become very territorial and exhibit aggressive behavior to establish territories (Shapovalov and Taft, 1954) in or below riffles, where food production is greatest" (Moyle et al., 2008). An approximately equal proportion of young-of-the-year (34%), age 1+ (37%), and age 2+ (27%) steelhead have been observed migrating downstream in the Trinity River (U.S. Fish and Wildlife Service, 2001), while results of scale analysis indicates that most steelhead (86%) in the Klamath River basin migrate as 2 year olds (Hopelain, 1998). Juvenile habitat requirements of KMP steelhead are similar to those of Northern California steelhead.

KMP steelhead also express a "half-pounder" life history strategy where subadults spend 2–4 months in the Klamath estuary or nearshore marine environments before returning to overwinter within the river. After overwintering in the lower and mid-

Klamath regions, they return to the ocean the following spring and spend 1 to 3 years there before returning to spawn (Moyle et al., 2008). Because of their over-summering behavior and extended residence time in fresh water, KMP summer steelhead are particularly susceptible to human activities and factors contributing to their decline include poaching, placer mining, logging, harvest, and disturbance from swimmers and rafters. Factors affecting KMP winter-run steelhead include dams, diversions, logging, agriculture, hatcheries, and harvest. (Moyle et al., 2008.)

Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*)

Lahontan cutthroat trout are native to the greater Lahontan basin in eastern California, southern Oregon, and northern Nevada (Trotter, 2008 in Moyle et al., 2008). In the Carson, Walker, and Truckee basins, only a few scattered streams contain Lahontan cutthroat trout (Trotter, 2008 in Moyle et al., 2008). Lahontan cutthroat trout also have been planted and established in a few creeks outside their historic range, including west-slope drainages near the Truckee basin (Moyle et al., 2008).

Lahontan cutthroat trout occur in a wide variety of cold-water river and lake habitats, including alkaline (e.g., Pyramid and Walker Lakes) and alpine oligotrophic lakes (e.g., Lake Tahoe and Independence Lake) (Moyle et al., 2008). Lahontan cutthroat trout primarily occupy streams with well-vegetated and stable stream banks and pools with close proximity to cover, as well as riffle-run complexes for spawning and cover (U.S. Fish and Wildlife Service, 1995a). Lake residents are adapted to a wide variety of lake habitats with optimal average mid-summer epilimnion temperatures of less than 22°C and a mid-epilimnion pH of 6.5 to 8.5 (Moyle et al., 2008). They can tolerate alkalinity and total dissolved solid (TDS) levels as high as 3,000 milligrams per liter (mg/L) and 10,000 mg/L, respectively (Koch et al., 1979 in U.S. Fish and Wildlife Service, 1995a).

Whether Lahontan cutthroat trout reside in rivers or lakes, they spawn in river habitats from April to July, depending on stream flow, water temperature, and elevation (U.S. Fish and Wildlife Service, 1995a). Spawning migrations are observed at water temperatures between 5°C and 16°C (U.S. Fish and Wildlife Service, 1995a). Preferred water depths for redds average 13 cm, and velocities average 56 centimeters/second (cm/sec) (Schmetterling, 2000; Moyle et al., 2008), while gravel substrate ranges from 6 to 50 mm (Coffin, 1981 in Moyle et al., 2008). Water must be saturated with oxygen and have minimal siltation to prevent eggs from suffocating. Eggs hatch after 4 to 6 weeks, depending on water temperature, and fry emerge from the gravel after 13 to 23 days (U.S. Fish and Wildlife Service, 1995a). Fry can spend up to 2 years in their natal stream before migrating to lake environments, but most migrate at the end of their first summer (Trotter, 2008 in Moyle et al., 2008). Females reach reproductive maturity at age 3 to 4 years, while males mature at 2 to 3 years. Consecutive year spawning is unusual, and only 50% of surviving females spawn again as compared with 25% of males (U.S. Fish and

Wildlife Service, 1995a). Lahontan cutthroat trout generally live 4 to 9 years; stream-dwelling fish have shorter life spans than lake-dwellers (Moyle et al., 2008). Both larval and adult phases feed primarily on terrestrial and aquatic invertebrates but also on oligochaetes and zooplankton (U.S. Fish and Wildlife Service, 1995a). Large Lahontan cutthroat trout also feed on juvenile fish of other species (Moyle et al., 2008).

Factors affecting Lahontan cutthroat trout abundance and habitat are the introduction of nonnative trout, overexploitation, logging, dams and diversions, grazing, mining, loss of genetic diversity, and disease (Moyle et al., 2008).

Paiute Cutthroat Trout (*Oncorhynchus clarkii seleniris*)

The historical distribution of the Paiute cutthroat trout is limited to 9.1 miles of habitat in Silver King Creek from Llewellyn Falls downstream to Silver King Canyon as well as the accessible reaches of three small named tributaries: Tamarack Creek, Tamarack Lake Creek, and the lower reaches of Coyote Valley Creek downstream of barrier falls (USFWS, 2004, Ryan and Nicola, 1976, Behnke and Zarn, 1976, Behnke, 1992, Moyle, 2002).

Currently, Paiute cutthroat trout are found only where they have been introduced outside their historic range. They occupy approximately 20.6 miles of habitat in five widely-distributed drainages. The present distribution in the Silver King Creek Watershed consists of populations in Upper Silver King Creek above Llewellyn Falls (2.7 miles total), Fly Valley Creek (1.1 miles), Four Mile Canyon Creek (1.9 miles), and Bull Canyon Creek (0.6 miles), as well as below the falls including Coyote Valley Creek (3.0 miles) and Corral Valley Creek (2.2 miles). There are four self-sustaining, pure populations outside the native drainage in the North Fork of Cottonwood Creek (3.4 miles), Cabin Creek (1.5 miles) (Inyo National Forest, Mono County), Stairway Creek (2 miles) (Sierra National Forest, Madera County), and Sharktooth Creek (2 miles) (Sierra National Forest, Fresno County) (U.S. Fish and Wildlife Service, 2004a).

Little Kern Golden Trout (*Oncorhynchus mykiss whitei*)

The Little Kern golden trout is native to the Little Kern River and its tributaries and developed as a distinct form through isolation when the connection to the San Joaquin dried up around 10,000 years ago. Historically the Little Kern golden trout were found in 100 miles of stream above the natural waterfall barrier at the mouth of the Little Kern River. Populations of the Little Kern golden trout currently are in the entire historical distribution of the subspecies, including additional habitat above natural barriers. Little Kern golden trout are at low risk to the future threats of resources extraction, energy development and land conversion (Fesenmyer, 2009a).

The principal habitat of the Little Kern Golden trout (as well as the Volcano Creek [California] Golden Trout below) is streams in the Kern Plateau at elevations above 2,300 m. These streams are generally broad, flat, exposed with little riparian vegetation and meander through meadows. The substrate of these streams is generally sand, gravel, and some cobble. The water is generally clear and cold. Golden trout mature in their third or fourth year and spawn when water temperatures are between 10 and 15 degrees Celsius and high spring flows decline, usually between mid-May and June. Females dig wide, shallow redds in smaller substrates. Spawning activity is highest during midafternoon, when water temperatures are highest (Moyle, 2002).

The Little Kern golden trout is at low to moderate risk since the entire distribution lies within the Golden Trout Wilderness Area of Sequoia National Forest, Sequoia National Park, and Giant Sequoia National Monument. The lone source of habitat degradation is the road network that exists in the Fish Creek and Clicks Creek watersheds (Fesenmyer, 2009a).

California (Volcano Creek) Golden Trout (*Oncorhynchus mykiss aguabonita*)

The California golden trout are found in two basins in the Kern River system; Golden Trout Creek (formerly known as Volcano Creek), a tributary of the mainstem Kern River, and the South Fork Kern River. The Kern River basin was once connected to the San Joaquin River, but the connection between the two dried up around 10,000 years ago and natural barriers between the systems began to develop. Three distinct forms of trout developed, including the California golden trout. Although the species natural range spans two basins, the two populations were once connected and only isolated thousands of years ago by lava flow that diverted a portion of the headwaters of the South Fork Kern River into the mainstem Kern River. Due to restoration efforts and protected lands in the current range of the golden trout, the golden trout are at low risk to future threats of resource extraction, energy development, and land conversion (Fesenmyer, 2009b).

The general habitat and breeding biology of the Volcano Creek golden trout are described above in the "Little Kern Golden Trout" description.

Eagle Lake Rainbow Trout (*Oncorhynchus mykiss aquilarum*)

The Eagle Lake rainbow trout is endemic to Eagle Lake, Lassen County, California, and its main tributaries, Pine creek and Papoose Creek. Introduced in numerous sites in northern and central California, and in other states and Canada, but these populations are maintained from hatchery stock (likely there is no natural reproduction of genetically pure stock) (NatureServe, 2009).

Eagle Lake is an alkaline lake, 24 kilometer (km) long and 3–4 km wide, consisting of 3 basins, the deepest of which is nearly 30 meters (m); in summer, most trout are in the deeper cooler waters of the deepest basin. Species is a stream spawner. Formerly spawned in the shaded, gravelly upper reaches of Pine Creek, where the young spent 1–2 years before moving down into the lake. Zooplankton and benthic invertebrates, especially leeches and amphipods, dominate the diet of Eagle Lake rainbow trout in their first year in the lake. By August, young-of-the-year tui chubs are the principal food for most individuals (NatureServe, 2009).

Two populations of Eagle Lake rainbow trout exist—a hatchery dependent lake population and low densities of escaped and experimental adults and their offspring in the headwaters of Pine Creek. Eagle Lake rainbow trout are at moderate risk to the future threats of forest management, wind development, land conversion, and drought and temperature changes related to climate change. The largest threats to the future security of the species are introduced species, changes to the fire regime and winter flooding associated with potential climate change (Fesenmyer, 2009c).

Kern River Rainbow Trout (*Oncorhynchus mykiss gilberti*)

Little information is available on the Kern River rainbow trout's life history or habitat requirements, but it is probably similar to other rainbow trout in these regards (Moyle et al., 1995).

The Kern River rainbow trout is endemic to the Kern River and its tributaries. It once existed in the Kern River as far downstream as Keyesville (below Lake Isabella Dam), and on the South Fork of the Kern River, upstream as far as Onyx. Remnant populations live in the Kern River from Durrwood Creek Junction Meadow, in Rattlesnake and Osa creeks and possibly upper Peppermint Creek and Salmon Creek. Much of the remaining habitat for the Kern River rainbow trout is in Sequoia National Forest and Sequoia National Park (Moyle et al., 1995).

Efforts are being made to identify streams still retaining Kern River rainbow trout and extensive collections of fish for genetic analysis were made 1991–1993. A management plan for the upper Kern River basin (above Isabella Reservoir) was completed in 1995 (Moyle et al., 1995). Problems addressed in the plan include grazing in riparian areas and heavy recreational use of the basin. Population surveys to monitor trout populations and identify habitats in need of protection are scheduled on a five-year interval. To reestablish populations of Kern River rainbow trout, anglers are now allowed to keep only two fish with a maximum length of 10 inches in most of the upper basin, DFG ultimately plans to replace nonnative rainbow trout stocked in tributary streams with catchable size Kern River rainbow trout if hatchery production of the native trout is successful According to the management plan, if native hatchery production is unsuccessful, stocking of nonnative rainbow trout will stop (Moyle et al., 1995).

Threats to remaining populations of Kern River rainbow trout are introgression with nonnative rainbow trout, habitat losses from poor management and events such as floods, droughts and fires. Some of its current habitat suffered from the landslides that filled in pools and silted spawning areas as a result of the Flat Fire of 1976. Introduced Beaver have significantly altered the river in Kern Canyon in Sequoia National Park, flooding meadows and increasing meandering in the channel (Moyle et al., 1995).

Goose Lake Redband Trout (*Oncorhynchus mykiss* ssp. 1)

The Goose Lake redband trout is native to the Goose Lake basin in California and Oregon and its tributaries; upper Pit River and headwater tributaries; and the south fork Pit River drainage (California Department of Fish and Game, 2007). Within the range of this species, there are no DFG hatcheries, and present stocking only occurs in the south fork Pit River drainage. Berg (1987) reported that Joseph, Parker, and East Creeks, tributaries of the upper Pit River in California, contained trout genetically similar to Goose Lake redband.

The Goose Lake redband trout has two ecological types: a relatively large lake-dwelling form (up to 45–50 cm tail length) and a smaller stream-dwelling form (generally <25 cm tail length) (Moyle et al., 2008; Moyle et al., 1995). According to Moyle et al., (1995), the lake-dwelling form lives in Goose Lake and spawns in the tributaries and headwaters of Lassen and Willow Creeks, none of which are within trout stocking locations. Therefore, no additional information is necessary regarding the life history and potential limiting factors for this lake-dwelling form.

The stream-dwelling form presumably has similar ecological requirements (e.g., cool, clean, fast-flowing water with plenty of cover; a high proportion of riffles with some deep pools for holding in the summer; and an abundant and diverse invertebrate supply) and life histories (e.g., spawn timing and sexual maturity) as other nonanadromous rainbow trout found in small, high-elevation streams. Redband trout can survive extended durations of warm temperatures (15°C–20°C), short durations at high temperatures (29°C), and high alkalinity and turbidity that would be lethal to other trouts (Moyle et al., 1995).

Goose lake redband trout presumably reach sexual maturity in their third year and live to 4 or 5 years old (Moyle et al., 1995). Spawning generally occurs from March through June but may occur at almost any time of the year except during high summer temperatures (Marshall 2008). Egg incubation through fry emergence can range from 5 to 7 weeks at temperatures ranging from 10°C–15°C (Moyle, 2002). Newly emerged fry and juveniles generally prefer low-velocity, shallow stream margins and shift to runs and pools as they become larger (Moyle, 2002; U.S. Forest Service, 1998). Goose Lake redband trout live up to 5 years and eat insects, insect larvae, and nymphs (California Department of Fish and Game, 2007a).

Factors affecting Goose Lake redband trout abundance and habitat are stream channelization, habitat degradation/fragmentation, grazing, water diversions, and introduced species (Moyle, 2008; U.S. Forest Service, 2007).

Mountain Whitefish (*Prosopium williamsoni*)

Mountain whitefish are widely distributed throughout the west, but in California they occur in lakes and streams on the east side of the Sierra Nevada in the Truckee, Carson, and Walker River drainages (Moyle, 2002).

Mountain whitefish typically live 5-10 years, however the oldest recorded was 17 years of age (Moyle, 2002). They reach sexual maturity in 2 to 4 years. Drops in water temperature initiate spawning, usually in October through early December when the water reaches 1-11˚C (Moyle, 2002). Adults then move up tributaries to riffles or wave washed areas of lakes greater than 75cm, with coarse, gravel, cobble, or rocks less than 50cm in diameter (Moyle, 2002). They do not build nest, but rather let their eggs sink into the spaces in the substrate. Newly hatched fish spend their first few weeks in shallow backwaters, and move to deeper and faster water as they grow. Their diet consists mainly of aquatic insects, such as chironomid midge larvae, and larger fish will eat larger invertebrates such as crayfish (Moyle, 2002).

Mountain whitefish are still common in California, however their populations are fragmented due to the construction of dams (Moyle, 2002).

FRESHWATER FISHES

Modoc Sucker (*Catostomus microps*)

The Modoc sucker occurs only in portions of Turner and Rush Creeks, which are two small drainage systems in Modoc County. These tributaries include Washington, Hulbert, and Johnson Creeks and two smaller, unnamed feeder streams.

Optimal habitat for Modoc suckers includes low- to moderate-flow streams that have large shallow pools, ample cover (e.g., riparian vegetation or undercut banks), soft sediments, and moderately clear water (Beacham et al., 2000; Moyle, 2002). As stream habitat in lower reaches may dry up in the summer, Modoc suckers need adequate water flow and optimal temperatures to migrate upstream during April and May to spawn and find refuge. After spawning, eggs adhere to the bottom substrate. Sexual maturity usually occurs at age 3, although males may mature sooner, and they only live for 4 to 5 years. Adult suckers are bottom feeders that forage on bottom-dwelling invertebrates, such as chironomid larvae, crustaceans, and aquatic insects, along with algae, diatoms, and detritus (Beacham et al., 2000).

The decline of the Modoc sucker has occurred in response to habitat degradation and hybridization with the more common Sacramento sucker (*Catostomus occidentalis*). In addition, the introduction of brown trout has added competitive pressure for resources and space (Beacham et al., 2000).

Lost River Sucker (*Deltistes luxatus*)

Lost River suckers are primarily found in large lakes in the Lost River and Klamath River drainages. There are populations in Tule Lake, Upper Klamath Lake, Lower Klamath Lake, Copco and Iron Gate Reservoir (Moyle, 2002).

Their ideal habitat is shallow, clear lakes with cool temperatures and moderate alkalinity where they forage on invertebrates among vegetation beds. Adults are at least 5 years old before they spawn. Spawning is triggered by increased inflow from tributary streams. Spawning typically takes place in riffles or runs over gravel between 1 female and several males. Larvae hatch out and start migrating downstream to a lake, where they seek refuge and feed in beds of emergent plants (Moyle, 2002).

Lost River suckers are both state and federally listed as endangered. They have lost spawning habitat through the destabilization of banks from grazing, dams blocking upstream and downstream migration, and diversion of water. They also have been overfished (Moyle, 2002).

Shortnose Sucker (*Chasmistes brevirostris*)

Shortnose suckers are native to the Upper Klamath River and Lost River basins in Oregon and California. There are populations in Clear Lake Reservoir, Boles Creek, Willow Creek, and Tule Lake (Moyle, 2002).

Shortnose suckers are adapted for life in large, shallow lakes that are cool, clear, well oxygenated, and are moderately alkaline, with bottoms dominated by large beds of aquatic vegetation. Adult shortnose suckers feed primarily upon zooplankton, especially cladocerans. Shortnose suckers can grow to about 50 cm fork length (measured from the tip of the snout to the end of the middle caudal fin rays), although fish over 45 cm fork length are unusual today. The shortnose sucker has been officially declared Endangered by both federal (1988) and state (1974) governments.

Santa Ana Sucker (*Catostomus santaanae*)

The Santa Ana sucker is native to the Los Angeles and Santa Ana basins in southern California, where it is restricted to three geographically separate populations in

three different stream systems. One population resides in the lower and middle Santa Ana River; the second population is in the east, west, and north forks of the San Gabriel River; and the third is in the lower Big Tujunga Creek. The species also is reported to occur in the Santa Clara River (Moyle et al., 1995).

Santa Ana suckers primarily occupy shallow waters in rivers and streams. When flooding occurs, suckers move into quiet marginal refuges and move back into the main stem once waters are less turbulent. Substrates range from gravel to boulders, with plenty of algae growth (Moyle et al., 1995).

Santa Ana suckers can become sexually mature during their first year and are highly fecund, producing between 4,400 and 16,000 eggs at a time. Spawning peaks between late May and early June, and eggs hatch within 15 days of fertilization. The suckers live for between 2 to 4 years. Their diet consists of mostly detritus and algae, eating only a very small amount of insect larvae and fish eggs (Moyle et al., 1995; Moyle, 2002).

The Santa Ana sucker is threatened primarily by the elimination or alteration of its stream habitats, reduction or alteration of stream flows, pollution, and introduction of nonnative species. The decline of this species indicates the poor state of the streams in the Los Angeles basin, which suffer from multiple and cumulative effects of many human-induced and natural changes (Moyle et al., 1995).

Owens Sucker (*Catostomus fumeiventris*)

The Owens sucker is native to the Owens River watershed in eastern California, where the species is most abundant in Crowley Reservoir (Mono County; reservoir formed by dam on Owens River) and widely distributed in the Owens River, Bishop Creek, and other streams in the Owens Valley (NatureServe, 2009). Its range also includes Convict Lake (Mono County) and Lake Sabrina (Inyo County) (NatureServe, 2009). In the 1930s an Owens sucker population became established in the Santa Clara River in Los Angeles County via the Owens Aqueduct and is apparently present in lower Sespe Creek, in the outflow of Fillmore Trout Hatchery, and in Piru Creek and Reservoir (NatureServe, 2009). Another introduced population occurs in June Lake in the Mono Lake Basin (NatureServe, 2009).

The Owens Sucker spawns from early May-early July (water temperatures usually 7–13°C) in tributary streams of Owens River and Crowley Lake (NatureServe, 2009). Habitat includes silty to rocky pools and runs of creeks (NatureServe, 2009). In the lower Owens River and tributaries, this sucker is most abundant in sections with long runs and few riffles, over substrates of mostly fine material (some gravel and rubble) (NatureServe, 2009). Adults occur in cool permanent streams with deep (1+ meters) pools and also do well in lakes and reservoirs, such as Convict Lake and Crowley Reservoir, where they seem to occur on the bottom at all depths (NatureServe, 2009). Larvae are abundant in weedy edges and backwaters of

streams. Spawning occurs in gravelly riffles in tributary streams; lacustrine populations spawn in springs and gravel patches along lake shores, as well as in tributary streams (e.g., Crowley Reservoir) (NatureServe, 2009). Diet and feeding are probably similar to those of *C. tahoensis*, which feeds on algae, detritus, and small benthic invertebrates (NatureServe, 2009).

The Owens sucker is abundant and widespread in its native range. In its established introduced populations, this species is likely relatively stable or slowly declining. This species is ecologically flexible and has adapted to and thrives in reservoir habitat. However, a large part of the population depends on reservoirs dominated by introduced game fishes and may suffer from competition or predation in the future (NatureServe, 2009).

Klamath Largescale Sucker (*Catostomus microps*)

The Klamath largescale sucker is native to the Klamath River and Lost River-Clear Lake systems of Oregon and California. They are found in California mainly in the Lost River basin and in the Klamath River downstream to Iron Gate Reservoir. Largescale suckers may be present in the lower Klamath River (Moyle, 2002).

They are found primarily in large streams with higher water quality and may also be found in lakes. They are largely absent from the highly eutrophic Upper and Lower Klamath Lakes, except in areas where water quality is improved by tributary streams. As with other large *Catostomus* species, the Klamath largescale suckers are presumed to be benthic omnivores. Juveniles in Upper Klamath Lake were found to feed mainly on zooplankton. Spawning migrations occur from March through early May, depending on flows and temperatures. Upstream migrations can be lengthy, and spawning can occur through May. The Klamath largescale sucker is a species of Special Concern in California, and faces threats from highlight modified waters and predatory introduced fishes (Moyle, 2002).

Owens Pupfish (*Cyprinodon radiosus*)

The Owens pupfish is a small fish in the killifish family that rarely exceeds 2.5 inches in length. Its distribution is restricted to the Owens Valley portion of the Owens River, in Mona and Inyo Counties. The Owens pupfish was historically widespread throughout the Owens River system, occurring in springs, sloughs, irrigation ditches, swamps, and flooded pastures from Fish Slough in Mono County south to Lone Pine in Inyo County. There are currently 4 populations of Owens pupfish: Fish Slough (has 3 sub-populations), Mule Springs, Well 368, and Warm Springs (U.S. Fish and Wildlife Service, 2009).

Owens pupfish occupy most aquatic habitat where water is relatively warm and food is plentiful. Owens pupfish feed mostly on aquatic insects while congregated in

small schools. Adults are frequently found in deeper water than juveniles, but all life stages may be found in various microhabitats available in the environment. Spawning occurs in the spring and summer over soft substrate. Females lay 1-2 eggs at a time up to 200 times per day. Eggs incubate for approximately 6 days and hatch in warm water temperatures, 75-81 degrees Fahrenheit. They usually are able to spawn after their first winter, and their lifespan is usually not greater than one year (U.S. Fish and Wildlife Service, 2009).

Mohave Tui Chub (*Gila bicolor mohavensis*)

The Mohave tui chub is a small fish rarely exceeding 6.7 inches standard length with a stocky body, large, slightly concave head, and short rounded fins. Natural populations of the Mohave tui chub were restricted to the Mojave River during historic times. The only natural population that currently survives is in Soda Springs, near Baker, California. They have been introduced into several areas, including Lark Seep at the China Lake Naval Air Weapons Center, Camp Cady, and the California Desert Information Center in Barstow (Lovich, 1998).

Mohave tui chubs initiate spawning in March or April when water temperatures approach 64 degrees Fahrenheit, and spawning continues while water temperatures range from 63-79 degrees. Spawning occurs through the spring, and involves chubs releasing eggs over vegetation to which the eggs then become attached. Eggs hatch in about 6-8 days. Fry form small schools in shallow areas of their habitat. Mohave tui chubs are not as widely tolerant to desert conditions as other desert fish, like pupfish. Mohave tui chubs are usually associated with deep pools and slough-like areas of the Mojave River. They also prefer aquatic ditchgrass since it provides structure for egg attachment when spawning and also provides thermal shelter to fish during the summer. Threats to the Mohave tui chub include introduced species, such as the arroyo chub, that can hybridize with the tui chub, habitat alteration, and changes in flow rates and geomorphology caused by saltcedar invasion in the Mojave River system (Lovich, 1998).

Owens Tui Chub (*Gila bicolor snyderi*)

The Owens tui chub has been recorded throughout the Owens River basin in its tributaries, irrigation ditches, Owens Lake, and Owens River. Due to extensive hybridization throughout the basin, genetically pure and viable populations are now known from only two locations in Mono County, the headwater springs of Hot Creek, and approximately 8 miles of the Owens River below Long Valley Dam.

Unarmored Three-Spined Stickleback (*Gasterosteus aculeatus williamsoni*) and Santa Ana Threespine Stickleback (*Gasterosteus aculeatus santaannae*)

Unarmored three-spined sticklebacks are found in some southern California streams. Populations in the Santa Clara River, San Antonio Creek (Santa Barbara County) and Sweetwater River (San Diego County) are morphologically similar and can be included under this name (Moyle, 2002). Unarmored three-spine sticklebacks only occur in fresh water. They require clear, flowing, well-oxygenated water with associated pools and areas of dense vegetation or organic debris to provide adequate cover and food supply and water temperature less than 24°C. Juveniles congregate in backwaters among aquatic plants.

Stickleback generally spawn in the spring (April through July) and the male guards eggs in a nest made from algae and aquatic plants (Moyle, 2002). Current population numbers are unknown. Major threats include stream dewatering, pollution, habitat alteration, and introduction of predators and competitors. These factors are all tied to increased urbanization of the Los Angeles region (Moyle, 2002).

Rough Sculpin (*Cottus asperrimus*)

Rough sculpin are largely restricted to spring-fed tributaries of the Pit River in northeastern Shasta County. They are most abundant through Fall River system and Tule River, its major tributary. The rough sculpin prefers large, spring-fed streams where water is cool, deep, rapidly flowing, and clear. They are usually associated with gravel or sand bottoms and beds of aquatic plants. They are generally inactive during the day, staying near the bottom to ambush prey or hiding in sandy areas to escape predators. They are usually most active around dusk or dawn. Rough sculpins tend to eat midge and larvae (Moyle, 2002).

Spawning occurs between September and January in Fall River, but in Hat Creek spawning is usually from mid-February to early May. Nest sites occur from riffles to pools, often over active springs, with bottom substrates ranging from sand to cobble. Males choose a nesting site under a rock or submerged log, entice females to spawn with them, and leave a clutch of 800-3,000 eggs attached to the underside of the rock or submerged log. The development of the Fall and Pit Rivers for power production has reduced the habitat in certain areas that have been dewatered, but has increased the range of the species in areas around the reservoirs. Sediment washed into the Fall River from logging, grazing, and fires in the watershed can provide a threat to the rough sculpin, but is being dealt with cooperatively with landowners (Moyle, 2002).

Reticulate Sculpin (*Cottus perplexus*)

Reticulate sculpins occur mostly in coastal streams in Washington and Oregon. In California they are found only in a few creeks that drain into the Applegate River, which drains north into the Rogue River in Oregon. In these creeks the reticulate sculpin is the dominant sculpin species. Their overall distribution appears to be limited by the presence of other sculpins, with which they are rarely sympatric. Reticulate sculpin generally occupy small streams with moderate velocities, summer temperatures less than 70 degrees Fahrenheit, and sandy and gravelly bottoms. In the absence of other sculpin species, they tend to seek out gravel bottoms in riffles, generally near dense vegetative cover. When other sculpins are present, they tend to live in pools or along stream edges (Moyle, 2002).

Reticulate sculpin consume mostly aquatic insect larvae and occasionally other fish. Breeding occurs from March through May when stream temperatures exceed 45 degrees Fahrenheit. Eggs are laid on the underside of rocks and moderately embedded cobbles in pools and riffles. Males guard the nest from predators probably until the fry leave the nest (Moyle, 2002).

Arroyo Chub (*Gila orcuttii*)

Arroyo chub are native to the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita rivers, as well as Malibu and San Juan Creeks (Wells and Diana, 1975 in Moyle et al., 1995). Arroyo chub have been successfully introduced into the Santa Ynez, Santa Maria, Cuyama, and Mojave River systems and into other smaller coastal streams (Moyle, 2002). Arroyo chub are found in slow-moving or backwater sections of warm to cool (10°C to 24°C) streams with mud or sand substrates (Moyle et al., 1995). They primarily occupy streams with dense aquatic vegetation and water depths greater than 40 cm (Wells and Diana, 1975 in Moyle et al., 1995). Arroyo chubs are omnivores and are known to eat algae, insects, crustaceans, and nematodes (Moyle, 2002).

Arroyo chub breed more or less continuously from February through August, with peak spawning activity in June and July (Tres, 1992 in Moyle et al., 1995). Most spawning occurs in pools or in quiet edge water, at temperatures of 14°C to 22°C (Moyle et al., 1995). The eggs adhere to the bottom substrate and will hatch in 4 days at 24°C. (Moyle et al., 1995). After hatching, fry will cling to the bottom substrate until their yolk sack is fully absorbed and then will find refuge among emergent vegetation for the next 3–4 months (Tres, 1992 in Moyle et al., 1995). The next 3–4 months are spent in quiet water, usually among vegetation or other flooded cover. Female arroyo chub are larger than the males; they reach sexual maturity at age 1 to 2 and seldom live past the age of 4. The decline of the arroyo chub has been attributed to habitat degradation and fragmentation resulting from urbanization within the Los Angeles metropolitan area, and to competition with introduced species (Moyle et al., 1995).

Amargosa Pupfish (*Cyprinodon nevadensis amargosae*)

Amargosa pupfish are found entirely within the Amargosa river basin in southern California and Nevada, and is divided into isolated populations, six of which are recognized as subspecies. Amargosa pupfish are adapted to a wide variety of environments, including shallow streams with soft bottoms and heavy growths of algae and cattails. Pupfish are well-adapted to a wide variety of temperatures (including daily fluctuations of up to 15-20 degrees Celcius) and salinity levels (Moyle, 2002). Pupfish are diurnal feeders and consume mostly cyanobacteria, algae, and small invertebrates (UC Davis, 2010). Spawning behavior of the Amargoa pupfish varies depending on habitat. In the Amargosa River, pupfish spawn in groups. Males do not establish and defend territories, but instead direct females to the periphery or center of a group where spawning occurs (Moyle, 2002).

Hardhead (*Mylopharodon conocephalus*)

Hardhead are distributed widely in low- to mid-elevation streams in the main Sacramento–San Joaquin River drainage, as well as in the Russian River drainage. Their range extends from the Kern River to the Pit River. In the San Joaquin River drainage, populations are scattered in the tributary streams yet are absent from the valley reaches of the San Joaquin River (Brown and Moyle, 1987 in Moyle et al., 1995; Moyle and Nichols, 1973; Saiki, 1984). In the Sacramento River drainage, hardhead are present in most of the larger tributary streams, as well as in the Sacramento River.

Hardhead typically are found in undisturbed areas of small to large streams at elevations of 10–1,450 meters (Moyle and Nichols, 1973; Reeves, 1964). Hardhead primarily occupy clear pools >1 m deep with sand-gravel-boulder substrates and water velocities of less than 25 cm/sec (Knight, 1985 in Moyle et al., 1995; Moyle and Baltz, 1985; Moyle and Nichols, 1973). In streams, adults tend to remain in the lower half of the water column (Knight, 1985 in Moyle et al., 1995; Moyle, 2002), while juveniles occupy shallow stream margins (Moyle and Baltz, 1985). Optimal stream temperatures are 24°C to 28°C (Knight, 1985 in Moyle et al., 1995; Moyle, 2002). Hardhead also need relatively high dissolved oxygen levels, which may limit their distribution to clear, deep streams and the surface waters of lakes and reservoirs (Cech et al., 1990 in Moyle et al., 1995; Moyle, 2002). Hardhead typically are found with Sacramento pikeminnow (*Ptychocheilus grandis*) and Sacramento suckers (*Catostomus occidentalis*) and are generally absent from streams containing nonnative fish species, especially centrarchids (Moyle and Daniels, 1982 in Moyle et al., 1995; Moyle and Nichols, 1973).

Hardhead become sexually mature in their third year (Moyle, 2002). Spawning may begin as early as April and extend as late as August, depending on location (Moyle et al., 1995; Moyle, 2002; Wang, 1986 in Moyle et al., 1995). Spawning is presumed to occur in gravel riffles (Moyle, 2002). The incubation period is unknown. Hardhead

are bottom feeders, and their diets are size-dependent. Small fish (<20 centimeters standard length [cm SL]) feed on mayfly larvae, caddisfly larvae, and small snails (Reeves 1964 in Moyle et al., 1995), and larger fish feed on aquatic plants, crayfish and other large invertebrates (Moyle et al., 1995).

A primary factor affecting hardhead populations is the introduction of predator fish—in particular, the smallmouth bass (Brown and Moyle, 1993 in Moyle et al., 1995; Gard, 1994 in Moyle et al., 1995; Moyle et al., 1995). Another factor is habitat loss due to dams and diversions, which create unsuitable temperatures and flow regimes and eliminate upstream spawning grounds (Moyle et al., 1995).

Mountain Sucker (*Catostomus platyrhynchus*)

Mountain suckers are generally found in clear streams 3-15 meters wide and less than 2 meters deep with moderate gradients and rubble, sand or boulder bottoms. Mountain suckers are also found in a variety of other waters, including turbid streams and large rivers. They generally feed on algae, diatoms, and small amounts of aquatic insects obtained by scraping food from the stream substrate. In California, the mountain sucker is native to Lahontan river basins, including Walker, Carson, Truckee, and Susan (Moyle, 2002).

Mountain suckers spawn between June and early August. To prepare for spawning, suckers move into small streams and feed on algae. Spawning occurs nocturnally in gravelly riffles upstream of deep pools. Fertilized eggs adhere to the gravel. Larval and juvenile mountain suckers are found near stream banks and in in beds of aquatic plants (Moyle, 2002).

Owens Speckled Dace (*Rhinichthys osculus* ssp. 1)

The Owens speckled dace has been extirpated from the majority of its historic range. It currently persists at two Long Valley sites (Whitmore Hot Springs and Little Alkali Lake), one east fork Owens River site near Benton (a spring on Mathieu Ranch/Lower Marble Creek), and several sites in the northern Owens Valley (North McNally Ditch, north fork Bishop Creek, an irrigation ditch in north Bishop, Lower Horton Creek, and Lower Pine and Rock Creeks) (Moyle et al., 1995).

Owens speckled dace are known to occupy a variety of habitats, ranging from second- to third-order cold water streams to hot-spring water systems, but are rarely found in water temperatures exceeding 29°C (Moyle et al., 1995). They also have been found in artificial habitats, such as irrigation ditches near Bishop. Speckled dace primarily occupy clear, well-oxygenated waters with abundant cover (e.g., rocks and aquatic and overhead vegetation) and areas of moving water resulting from stream current or waves (Moyle, 2002). They are bottom browsers that feed on small aquatic insects typically found in riffle habitats.

They typically become sexually mature at 2 years and spawn in June, July, and early August. Spawning generally occurs in shallow gravel areas, including riffle edges within streams or lake shorelines. Embryos hatch in about 6 days at temperatures of 18°C–19°C and emerge after 7–8 days. Owens speckled dace typically live 3 years but may live 6 or more years (Moyle, 2002).

Factors in the decline of Owens speckled dace populations include stream diversions, destruction of stream and riparian habitat by livestock, and predation by introduced fishes such as brown trout and green sunfish (Sada, 1989 in Moyle et al., 1995). Other introduced fishes that may be competitors or predators of speckled dace are largemouth bass (*Micropterus salmoides*), mosquitofish (*Gambusia affinis*), channel cattish (*Ictalurus punctatus*), and Sacramento perch (*Archoplites interruptus*) (Moyle et al., 1995).

Santa Ana Speckled Dace (*Rhinichthys osculus* ssp. 2)

The Santa Ana speckled dace was apparently once widespread in the upland (mountain, foothill) portions of the Santa Ana, San Gabriel, and Los Angeles river systems, Los Angeles and Orange counties, California. At least some local, widely scattered populations also formerly occurred on the Los Angeles Plain. The Santa Ana speckled dace is recently extirpated in the Los Angeles River drainage and is presently confined to the headwaters of the San Gabriel river and Santa Ana river, where it is in imminent danger of extirpation. This subspecies is also reported to be in the South Fork of the San Jacinto River, Riverside County, and this may be the second largest and best locality after the San Gabriel River. The Santa Ana speckled dace has been introduced into the Santa Clara and Cuyama rivers and River Springs on the east side of Adobe Valley, Mono County. The status of the introduced populations is not known, but the Santa Clara introduction apparently failed. This subspecies has been reported also from Pismo and Arroyo Grande creeks south of San Luis Obispo Creek (NatureServe, 2009).

The Santa Ana speckled dace is found in shallow gravel and cobble riffles of permanent flowing streams with summer temperatures of 17-20 C, where overhanging riparian plants provide cover. In the West Fork of the San Gabriel River, this subspecies is most common where other native fishes also are common. The Santa Ana speckled dace probably lives up to three years (NatureServe, 2009).

Unstable stream flows below Big Tujunga Dam and introduced red shiner have eliminated the Santa Ana speckled dace population in Big Tujunga Creek. The San Gabriel West Fork populations are low due to sediment releases from Cogswell Dam, and the area below the dam is managed as a catch and-release and put-and-take trout fishery. The population supported by the San Gabriel River, East Fork is currently the most robust population in the watershed. The greatest number of individuals is found above the confluence of the stream with Cattle Canyon Creek. Above this confluence, the stream is unaffected by dams or recreation (O'Brien pers.

comm.). Reduced flows in some areas restrict summer habitats to small stretches of stream and in dry years this may lead to extirpation of these populations. The Santa Ana speckled dace is also endangered by natural conditions such as drought, and the San Gabriel River populations are at risk of washing out if stabilizing vegetation is lost due to fires. Dams have fragmented populations and prevent them from intermixing even in wet winter conditions. Human recreational use is some areas is heavy enough to disrupt the spawning and feeding behavior of this subspecies (NatureServe, 2009).

Red Hills Roach (*Lavina symmetricus*)

The Red Hills roach is a recently discovered population of *L. symmetricus*, and is known to be restricted to spring-fed pools and tributaries of Six Bit Gulch in Tuolumne County. The construction of Don Pedro dam in 1921 created a barrier between the Red Hills population and other populations of the California Roach. The Red Hills roach populations in the tributaries were found to be morphologically distinct from nearby roach populations. Morphological, genetic and geographic sampling suggests that the Red Hills morphology may be mostly due to the Red Hills environment (Jones et al., 2002).

The Red Hills roach is a benthic omnivore that often feeds on algal tufts (Jones et al., 2002). Roach are generally found in mid-elevation streams in the Sierra foothills, streams, and are found in a diversity of habitats within a watershed, from cool headwater streams to warmer lower reaches. Spawning generally occurs between March and early July, depending on water temperature. The roach spawns in large groups and fertilized eggs hatch in 2-3 days (Moyle, 2002). Like other freshwater fish, it is impacted by habitat degradation and water diversion. The California roach in general is of little economic value, which makes funding for conservation of the population difficult (Jones et al., 2002).

Pit Roach (*Lavina symmetricus mitrulus*)

The Pit Roach has disappeared from much of its former range in the upper Pit River drainage, and is now found in scattered populations in small, isolated streams or in some sections of the Pit River that are regulated. The Pit roach are benthic-feeding omnivores, and consume aquatic insects, larvae, crustaceans, and algae (Moyle, 2002).

Pit roach usually mature at 2 or 3 years of age. Spawning occurs from March through early July, usually when temperatures exceed 60 degrees Fahrenheit. The Pit roach moves up from pools in to shallow flowing areas where the bottom is covered with small rocks. Spawning occurs in large groups, with females depositing a few eggs at a time into crevices between rocks (Moyle, 2002).

The principal threats to the Pit Roach include habitat loss (from grazing, construction, and water diversions) and introduced predators. Since populations are widely scattered, extinctions can occur locally due to natural factors without local recolonization (Moyle, 2002).

Clear Lake Hitch (*Lavinia exilicauda chi*)

Clear Lake hitch are a lake-adapted form of the hitch (*Lavinia exilicauda*) found in Clear Lake, Lake County, and associated lakes, and spawn in associated tributaries. Adult hitch are usually pelagic. Juveniles in Clear Lake are found in inshore shallow-water habitat and move into deeper offshore areas when they are approximately 40 and 50 mm standard length (Moyle, 2002).

During the breeding season in adult Clear Lake hitch migrate into lower reaches of low-gradient gravel-bottomed intermittent streams to spawn during the summer. Hitch runs are easily blocked by dams and other structures that impede upstream migration, since they are not aggressive swimmers. The main threats to the Clear Lake hitch are loss of spawning habitat and nursery areas. The intermittent streams where Clear Lake hitch breed go dry earlier in the season from stream diversions and, which can cause spawning failures during dry years and can potential seriously affect the hitch (Moyle, 2002).

Jenny Creek Sucker (*Catostomus rimiculus* spp.)

Jenny Creek suckers are an isolated population of the Klamath smallscale suckers. Jenny Creek suckers are found in in the 546 km^2 Jenny Creek watershed, separated from the Klamath River by a natural 10 meter waterfall. A small portion of the Jenny Creek watershed is within California, from the waterfall above Irongate Reservoir on Jenny Creek to the California-Oregon State Border. The Jenny Creek sucker was found to grow slower, mature later, and grow smaller than the upper Klamath River smallscale suckers (Rossa and Parker, 2007).

It is likely that the Jenny Creek sucker has a similar life history to other suckers and prefers deep, quiet pools of main channels and slower moving stretches of tributaries. The Jenny Creek sucker has been observed feeding in schools along stream bottoms, and generally consumes benthic macroinvertebrates, algae, and organic matter. The Jenny Creek sucker presumably migrates up tributary streams to spawn in the spring (Moyle, 2002). Since the Jenny Creek sucker is a small isolated population, recent observations of low numbers of spawning adults with inconsistent spawning success mean that population numbers could drop considerably (Rossa and Parker, 2007).

AMPHIBIANS

Sierra Madre and Sierra Nevada (mountain) Yellow-Legged Frog (*Rana muscosa*, including *Rana sierrae*)

For several years, the USFWS has recognized two DPSs of mountain yellow-legged frog: the southern DPS, also known as the Sierra Madre yellow-legged frog, and the northern DPS, also known as the Sierra Nevada yellow-legged frog, which is segregated by some authorities as the distinct species *Rana sierrae*. Populations in the southern DPS have declined from about 166 documented localities in southern California (Jennings and Hayes, 1994; 67 FR 44382) to only seven known locations in portions of the San Gabriel, San Bernardino, and San Jacinto Mountains (Backlin et al., 2002 in 67 FR 44382). Conversely, the northern DPS ranges from southern Plumas County to southern Tulare County and extends into Nevada in the vicinity of Lake Tahoe and northward to the slopes of Mount Rose (U.S. Fish and Wildlife Service, 2003b). The native habitat for the northern DPS is almost entirely outside the range of introduced fish (Knapp, 1996).

Frogs in the southern DPS occupy mostly stream habitats that run through narrow canyon environments (Grinnell and Camp, 1917 in Vredenburg et al., 2008) and chaparral belts (Zweifel, 1955). Frogs in the northern DPS occupy meadows, streams, and lakes (Wright and Wright, 1933), usually within 1 m of the water's edge. Both adults and tadpoles are found most frequently in shallow water areas (Bradford, 1984). Frogs in the northern DPS have been known to overwinter in various places, including the bottoms of lakes, rocky stream environments (Vredenburg et al., 2005), and rock crevices (Matthews and Pope, 1999), but the latter behavior may be a response to the presence of fish.

Spawning occurs from April at lower elevations to June–July at higher elevations (Stebbins, 1951 in Vredenburg et al., 2008; Wright and Wright, 1933; Zweifel, 1955). Zweifel (1955) has reported that first reproduction is most likely at around 3 years of age. In the northern DPS, egg masses are deposited in areas where they are completely submerged either under banks or attached to submerged objects, such as boulders, logs, or vegetation (Stebbins, 1951 in Vredenburg et al., 2008; Wright and Wright, 1949; Zweifel, 1955). Since the tadpoles overwinter, breeding sites are permanent lakes and ponds where bottom waters do not freeze; such waters are over 1.7 meters deep and usually more than 2.5 meters deep (Bradford, 1983 in Vredenburg et al., 2005). Southern DPS populations are primarily stream dwelling, so they may not need deep, permanent waters, but their breeding requirements are currently unknown.

Incubation requires 18–21 days at temperatures of 5°C to 13.5°C (Zweifel, 1955). When tadpoles emerge, they take cover in mud, under rocks, under banks, or in submerged vegetation (Stebbins, 1951 in Vredenburg et al., 2008). The duration of the larval stage ranges from one (Storer, 1925) to several seasons, depending upon elevation and water temperature. However, throughout most of their range in the Sierra Nevada, three size classes are typically observed, and it appears that

metamorphosis generally occurs when tadpoles are 2.5 years old (Wright and Wright, 1933; Zweifel, 1955).

The diet of southern DPS frogs consists of invertebrates such as beetles, ants, bees, wasps, flies, true- bugs, and dragonflies (Long, 1970 in Vredenburg et al., 2008). Northern DPS frogs probably have a similar diet and also have been documented to occasionally eat Yosemite toad tadpoles (Mullally, 1953) and Pacific treefrog tadpoles (Pope, 1999 in Vredenburg et al., 2008). Tadpoles, unlike adults, are thought to be mostly herbivorous and detritivorous.

Several factors have been implicated in northern DPS population declines, including predation and competition with introduced trout (Drost and Fellers, 1996; Jennings and Hayes, 1994; Knapp, 1996; Knapp and Matthews, 2000), diseases including chytrid fungus, *Batrachochytrium dendrobatidis* (Berger et al., 1998; Rachowicz et al., 2006), air pollution from pesticide drift (Davidson and Knapp, 2007), livestock grazing (U.S. Fish and Wildlife Service, 2003b), UV-B radiation, and long term changes in weather patterns, especially concerning the severity and duration of droughts.

California Red-Legged Frog (*Rana draytonii*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Rana draytonii* (CaliforniaHerps.com, 2010a).
This frog was historically found along the coast and Coast Ranges from Mendocino County in northern California south to northern Baja California, and inland east through the northern Sacramento Valley into the foothills of the northern Sacramento Valley into the foothills of the Sierra Nevada mountains, south to Tulare County and possibly Kern County. They probably did not occur in the Central Valley due to annual flooding. *Rana draytonii* is found mainly near ponds in humid forests, woodlands, grasslands, coastal scrub, and streamsides with plant cover in lowlands or foothills from sea level to 5,000 feet.

Reproduction is aquatic with external fertilization. Mating and egg-laying occurs in permanent and temporary bodies of water; mostly ponds, but also marshes, lagoons, and slow-moving parts of streams. Breeding occurs from late November to April, depending on the location, and lasts for only a week or two. Females lay an average of 2,000 eggs in a large gelatinous cluster that is attached to plants near the water surface. Eggs hatch after about four weeks. Tadpoles metamorphose in four to seven months, but at some sites they overwinter and metamorphose the following summer.

Populations in the Sierra Nevada Mountains and in southern California have declined seriously possibly due to introductions of non-native predators such as bullfrogs and fish, habitat loss due to development and agriculture, and pesticide pollution. Windborne pollutants from agriculture in the Central Valley have

probably contributed considerably to the extirpation of the species in the nearby Sierra Nevada foothills. Much of this frog's prime habitat of foothills grassland has been developed in the Bay Area and in the Sierra Nevada foothills. As of 2009, only six recently discovered populations are known in the Sierra Nevada, and these were all discovered after 1997. Only two very small extant populations are known from South of Santa Barbara, one on the Santa Rosa Plateau in Riverside County, and one in Ventura County. The species apparently persists in northern Baja California (CaliforniaHerps.com, 2010a).

Foothill Yellow-Legged Frog (*Rana boylii*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Rana boylii* (CaliforniaHerps.com, 2010b).

This frog originally ranged from northern Oregon west of the Cascades south along the coast to the San Gabriel Mountains, and south along the foothills of the western side of the Sierra Nevada Mountains to the Tehachapi Mountains, with an isolated population (now possibly extinct) in the San Pedro Martir Mountains of Baja California. Currently, this frog is no longer found in the San Gabriel Mountains or along the coast south of Monterey County, and the few remaining populations in the foothills of the southern Sierra Nevada Mountains are nearly extinct.

Reproduction is aquatic. Fertilization is external. Mating and egg-laying occurs in streams and rivers (not ponds or lakes) from April until early July, after streams have slowed from winter runoff. In California, researchers (G. Fellers) have found egg masses between April 22nd and July 6th, with an average of May 3rd. Clusters of eggs are laid on the downstream side of rocks in shallow slow-moving water where they are attached to submerged rocks and pebbles and occasionally vegetation. Eggs can number from 300 - 2,000, averaging 900. Egg masses are often covered with a layer of silt, which probably helps to hide them from predators. Eggs hatch within 5 - 37 days, depending on water temperature. Tadpoles remain around the egg mass for a about a week, then they move away to feed, using rocks and gravel for cover. Tadpoles transform in 3 to 4 months, typically from July to October. Newly metamorphosed juveniles typically migrate upstream from the hatching site.

This frog has disappeared from much of its range in California (possibly up to 45 percent.) Populations south of southern Monterey County are now apparently extinct. Extremely high water levels in 1969 may have been one cause for that decline. *Rana boylii* is also gone from an estimated 66 percent of its range in the foothills of the Sierra Nevada Mountains, especially south of highway 80 where it is nearly extinct. Water released from reservoirs, that washes away eggs and tadpoles and forces adult frogs away from the streams leaving them more vulnerable to predators, is a serious problem for frogs in the Sierra Nevada foothills. Air-borne pesticides from the vast agricultural fields of the Central Valley are also likely to be a primary threat. Recreational activities along streams that alter streambeds,

especially gold mining, are also having a negative impact on frog populations in the Sierra foothills. Introduced fish also stress frog populations by consuming eggs and tadpoles, and introduced bullfrogs compete for food and eat the frogs. Habitat loss, disease, introduced crayfish, stream alteration from dams, mining, logging, and grazing, are also threats to this frog (CaliforniaHerps.com, 2010b).

Cascades Frog (*Rana cascadae*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Rana cascadae* (CaliforniaHerps.com, 2010c).

Historically, this frog was found in fragmented populations in extreme northern California, from the edge of the northern Sierra Nevada Mountains to Mt. Lassen, Mt. Shasta, the Marble Mountains, and the Trinity Alps. But it is not missing from an estimated 50 percent of its former range in California, and most of its former southernmost locations, including Mt. Lassen. Out of California, it ranges throughout the Cascades Mountains of Oregon and Washington, in the Olympic Mountains, and barely into British Columbia, Canada. The Cascades frog inhabits wet mountain areas in open coniferous forests to near timberline, including small streams, small pools in meadows, lakes, bogs, ponds, and marshy areas near streams. It is typically found in water with no predatory fishes.

Reproduction is aquatic. Fertilization is external. Cascades frogs overwinter near the breeding ponds, becoming active as the ice thaws. Breeding begins soon after the snow begins to melt, from March to mid August depending on the location. Breeding takes place in temporary and permanent bodies of water generally lacking fish, with silt or mud substrates, often in smaller bodies of water near larger lakes. Breeding is explosive, lasting only about a week or less at a location. Adults return to the same location each year to breed.

Adults are reproductively mature at 2 - 3 years. Females breed only once per year. Males sit in shallow water and make a faint advertisement call to attract females. Eggs are laid in a mass the size of an orange or small grapefruit containing 300 -800 eggs which is not attached to vegetation, but partly submerged in shallow water. Egg clusters are often laid in aggregations. Eggs are black above, and white below, and are widely spaced in the gelatinous mass. Tadpoles are speckled with dark spots. Tadpoles transform in about 2 months after hatching from the eggs. There is no documented evidence that tadpoles overwinter, but it is possible.

Although it is still common and apparently in no trouble in Oregon and Washington, the Cascades Frog is no longer present in approximately 50 percent of its historical range in California, and has disappeared from as much as 99 percent of their southernmost California populations, including Mt. Lassen, where they were once abundant. Numbers are small in extant populations. Introduced sport fish, airborne environmental pollution, solar UV-B radiation, fungal pathogens, and loss of open

meadow habitat due to fire suppression have all been suggested as factors contributing to the decline of Cascade Frogs in California (CaliforniaHerps.com, 2010c).

Arroyo Toad (*Bufo (=Anaxyrus) californicus*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Bufo californicus* (CaliforniaHerps.com, 2010d).

The Arroyo Toad is endemic to California and northern Baja California. Its range is west of the desert in coastal areas from the upper Salinas River system in San Luis Obispo County to northwestern Baja California. *B. californicus* inhabits washes, arroyos, sandy riverbanks, riparian areas with willows, sycamores, oaks, cottonwoods. The Arroyo toad has extremely specialized habitat needs, including exposed sandy streamsides with stable terraces for burrowing with scattered vegetation for shelter, and areas of quiet water or pools free of predatory fishes with sandy or gravel bottoms without silt for breeding.

Reproduction is aquatic and fertilization is external. Mating and egg laying takes place at the quiet margins of shallow streams from March to July. Breeding is not triggered by rainfall, but seems to require an increase in air and water temperature to above 11-13 degrees C (51.8 - 55.4 degrees F).

The Arroyo toad is estimated to be absent from 65 to 75 per cent of its historic range. It is possible that this number is even higher because the historic estimate may be based only on remaining populations, when toads actually also inhabited streams in areas that were urbanized or altered before the toads locations were known. Remaining population densities of this toad, once historically high, are now relatively low, especially at montane and foothill locations. They are a bit higher at coastal stream locations. These remaining populations are extremely vulnerable due to isolation from other populations, and to specialized habitat needs that include fragile sandy streamside habitat and streams that have not been heavily silted. The loss or degradation of this specialized habitat is a major problem. Causes for habitat loss include the results of mining, urban development, grazing cattle, and other sources of stream trampling such as excessive human recreational use, including campgrounds and vehicles driving across streams. Streamside trampling crushes and destroys all the juveniles, since they feed by remaining on sandy stream-banks. Exotic aquatic predators such as bullfrogs, fish and crayfish, also reduce toad populations (CaliforniaHerps.com, 2010d).

Black Toad (*Bufo (=Anaxyrus) exsul*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Bufo (=Anaxyrus) exsul* (CaliforniaHerps.com, 2010e).

This toad is endemic to California and has one of the smallest ranges of any North American Amphibian. It occurs naturally only in a few spring systems in Deep Springs Valley, Inyo County, at elevations of about 4,900 ft. (1,450 m) to 5,600 ft. (1,700 m.) According to the CA Dept. of Fish & Game, in 1998, a population of *B. exsul* was found in the Saline Valley in Inyo County, in Death Valley National Park, but was most likely introduced. The black toad inhabits springs and marshes in an isolated desert basin between the Inyo and White Mountains. Toads are sometimes found in surrounding grasses. The vegetation around these springs is sparse and conditions are very dry with sandy soil.

Reproduction is aquatic and fertilization is external. Mating and egg-laying occurs from late March into April or May in shallow water with vegetation to protect eggs and tadpoles. Eggs are laid in shallow waters bordering the larger wetlands. Eggs are laid in strings that are entwined in aquatic plants on or just below the surface. Eggs hatch in 5 days and larvae transform in 3 - 5 weeks. Tadpoles do not overwinter. Transformed juveniles remain in shallow marshy areas with the adults.

The population of Black Toads appears to be stable. This toad is listed as threatened because it occurs only in a small isolated population that is restricted to very limited and specialized habitat. If the springs that it depends on were to dry up, or if a disease or predator were introduced, the toad would most likely become extinct (CaliforniaHerps.com, 2010e).

Yosemite Toad (*Bufo (=Anaxyrus) canorus*)

Except where otherwise cited, the following information comes from the CaliforniaHerps.com description of *Bufo canorus* (CaliforniaHerps.com, 2010f).

The Yosemite toad is endemic to California in high elevations (between 4,800 to 12,000 feet elevation) in the Sierra Nevada Mountains from the Ebbets Pass area of Alpine County south to the Spanish Mountains area in Fresno County. The toad inhabits wet mountain meadows, willow thickets, and the borders of forests, and is usually not more than a hundred meters from perennial sources of water.

The toad's activity period is relatively short, from April - July, to late September or early October. After breeding, males and females move from the breeding pond into meadows where they feed for 2 - 3 months before the snows return. During winter, Yosemite Toads shelter in rodent burrows, willow thickets, forest edges adjoining meadows, and in clumps of vegetation near water. Calling males at breeding sites will defend their territory from other males. The Yosemite toad's diet consists of a wide variety of invertebrates, including beetles, ants, siders, bees, wasps, flies, and millipedes. The prey is located by vision, then the toad lunges with a large sticky tongue to catch the prey and bring it into the mouth to eat.

Reproduction is aquatic through external fertilization. Mating and egg-laying takes place in shallow pools and the margins of lakes or in quiet streams from May to July shortly after the snow melts. Males arrive at breeding sites a few days before females. Males set up a territory in shallow water and make a trilled breeding call to attract a female. Calls are made during the day, peaking midday. When a female arrives, the male amplexes her and rides her to a location where she decides to lay her eggs. The male fertilizes the eggs as she lays them, then they separate. Eggs are laid in shallow pools and slow moving meadow streams. Females laid an estimated 1,500 to 2,000 eggs at one location. Eggs are laid in single or double strands, or in a radiating network several eggs deep. Eggs hatch in 10 - 12 days. Tadpoles metamorphosed in 52 - 63 days at one location. Juvenile toads feed and overwinter near the breeding pond (CaliforniaHerps.com, 2010f).

Appendix K -References

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